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(54) **ECCENTRIC ROTOR AND VIBRATION MOTOR INCORPORATING THE ECCENTRIC ROTOR**

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H02K 7/065 (2006.01)

(52) **U.S. Cl.** **310/257**; 310/81; 310/254.1; 310/49.34; 310/49.22; 310/49.21

(58) **Field of Classification Search** 310/81, 310/257, 49.09, 49.19, 49.21, 49.22, 49.25, 310/49.34
See application file for complete search history.

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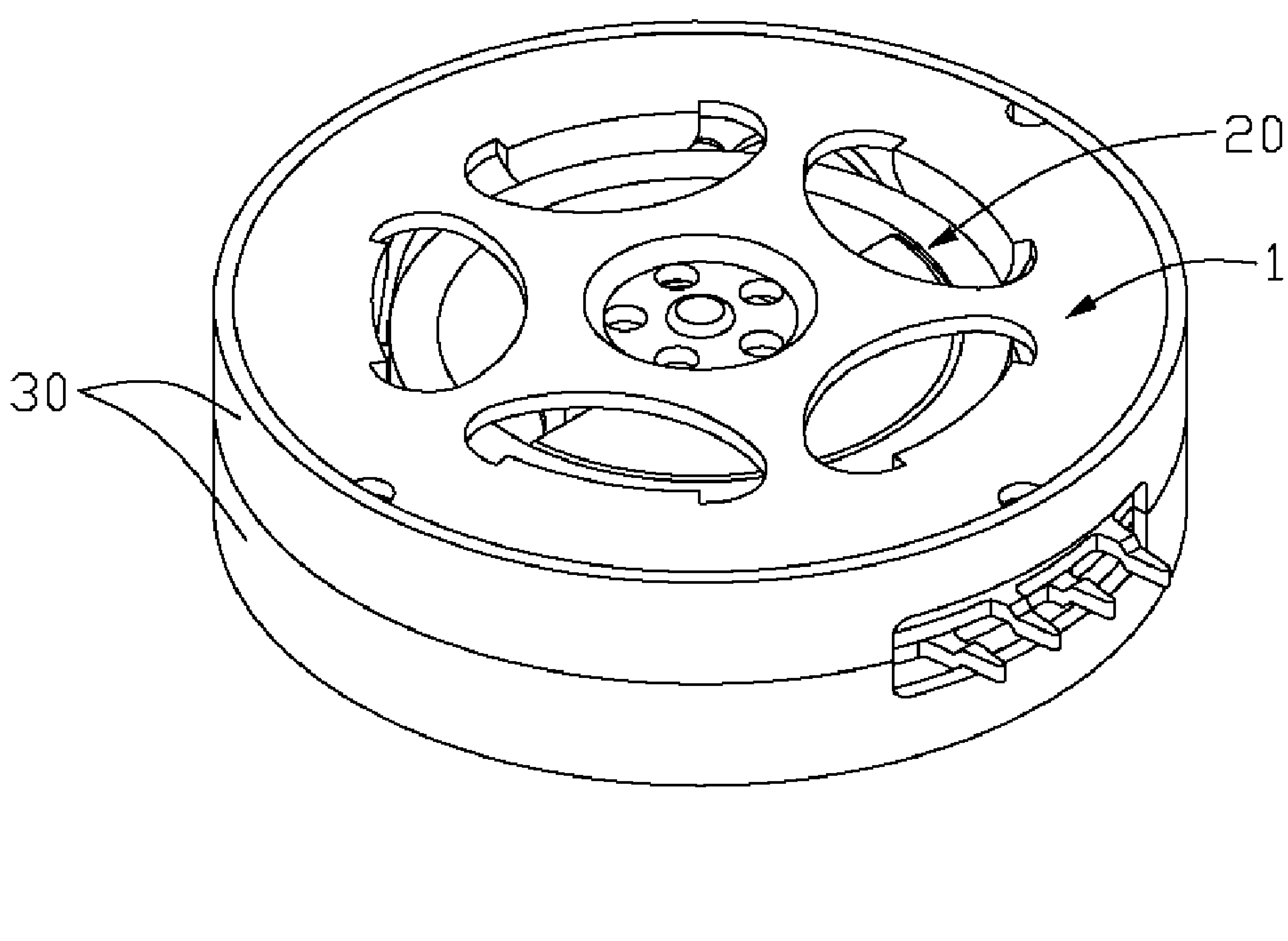
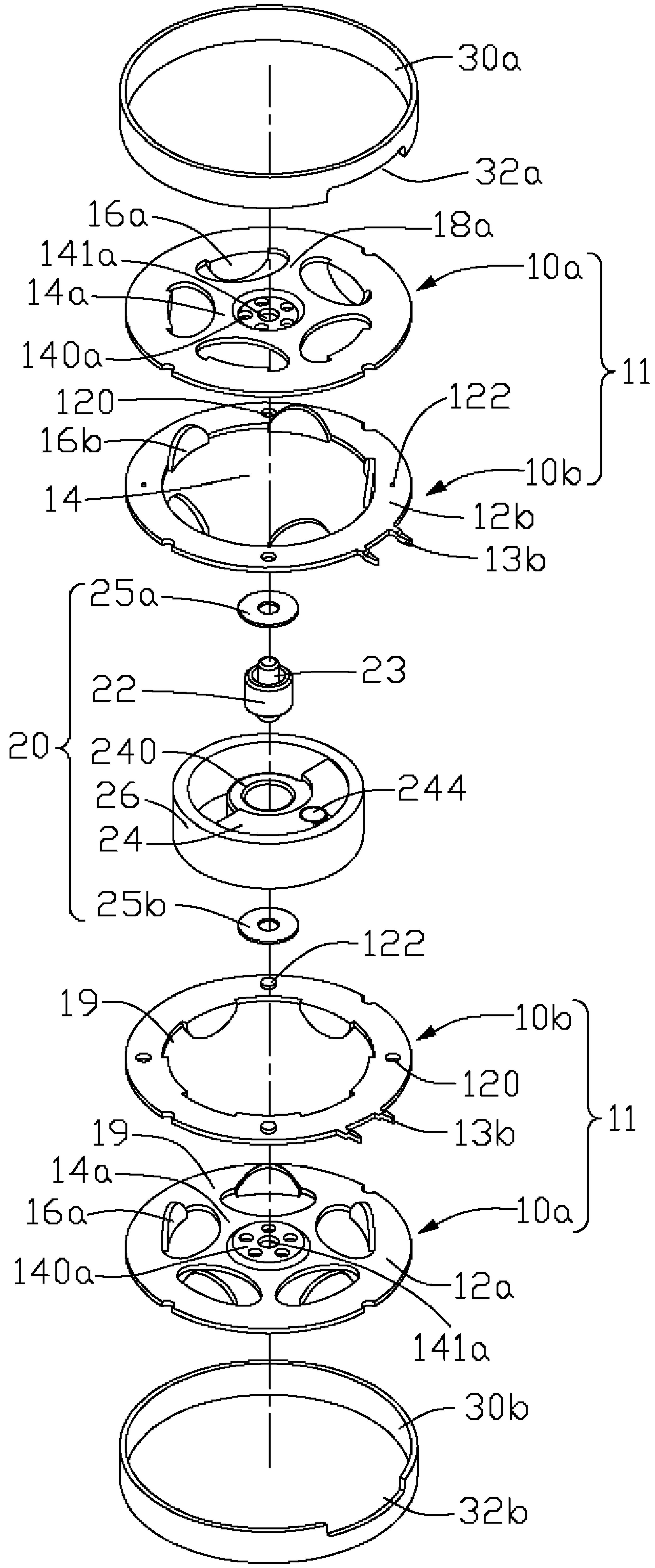
(57) **ABSTRACT**

A vibration motor includes a housing, a stator (**10**) received in the housing (**30**) and a rotor (**20**) rotatably disposed in the stator. The stator includes two claw-pole assemblies (**11**) arranged back-to-back, and a shaft (**23**) being fixedly connected with the two claw-pole assemblies. The rotor includes a bearing (**22**) rotatably mounted around the shaft, a permanent magnet (**26**) mounted around the bearing, and an eccentric weight (**24**) fixedly attached to the permanent magnet. The eccentric weight includes a main body (**240**) and at least one inserting portion (**244**) having a density higher than that of the main body.

13 Claims, 7 Drawing Sheets

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25b
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FIG. 1

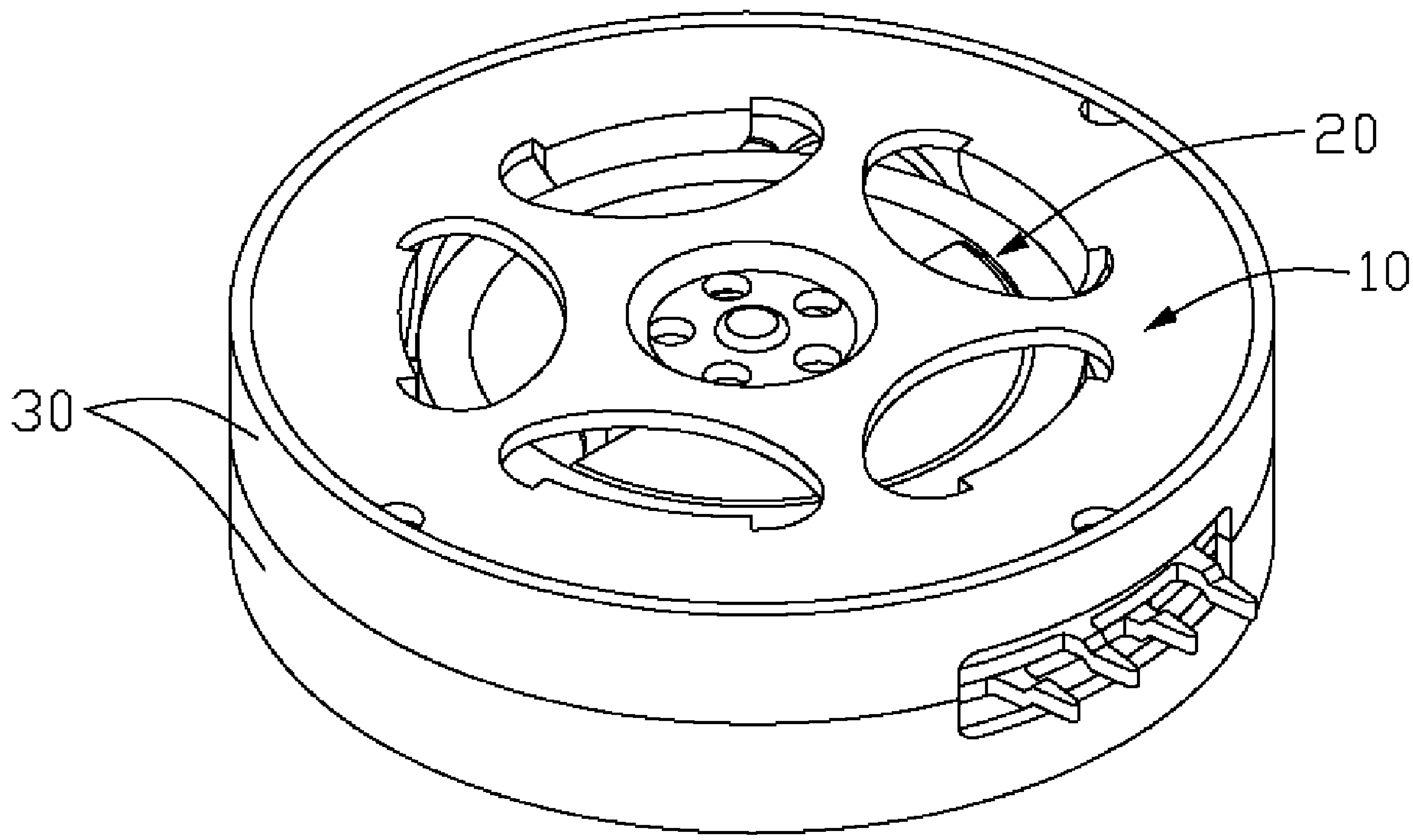

FIG. 2

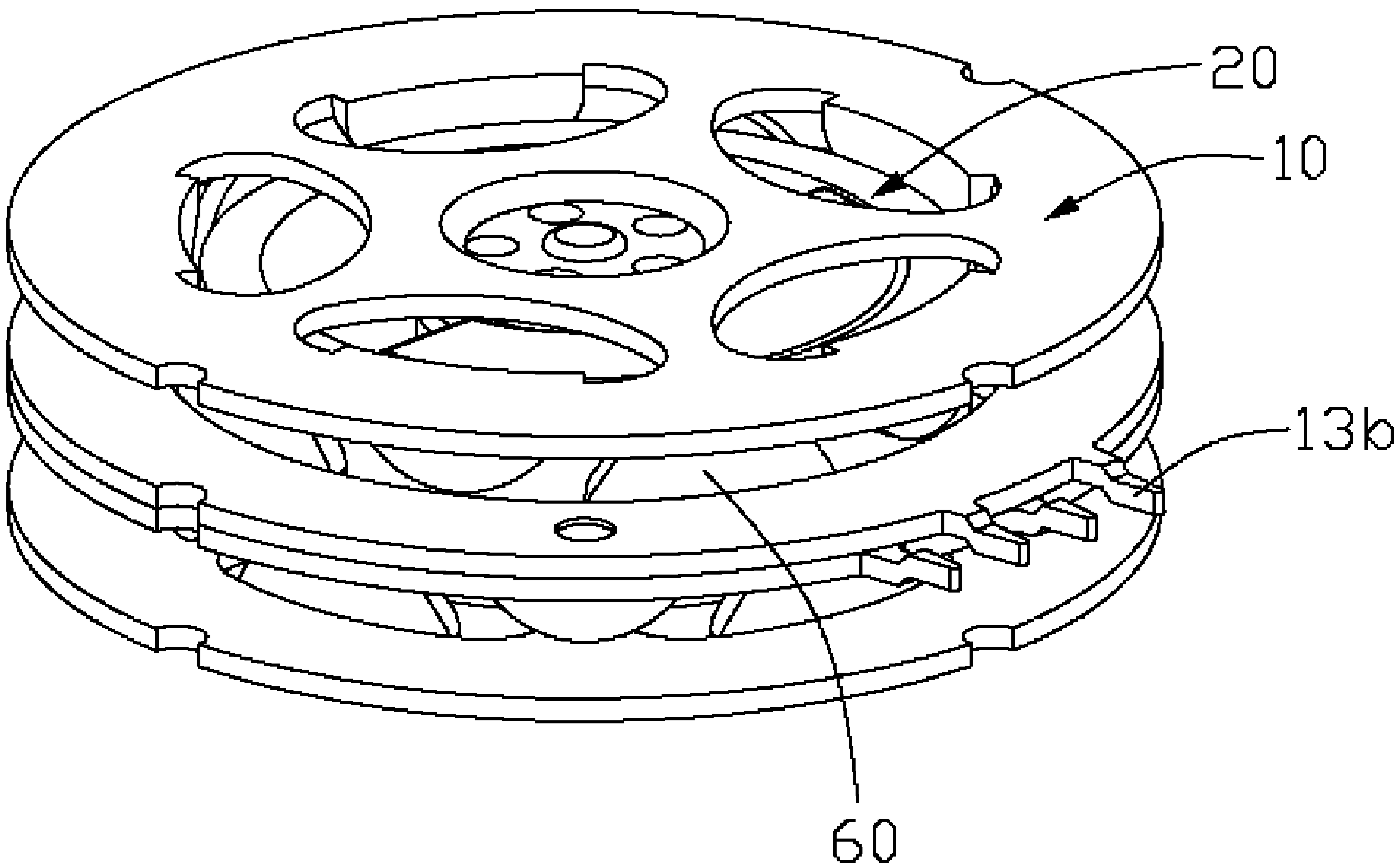

FIG. 3

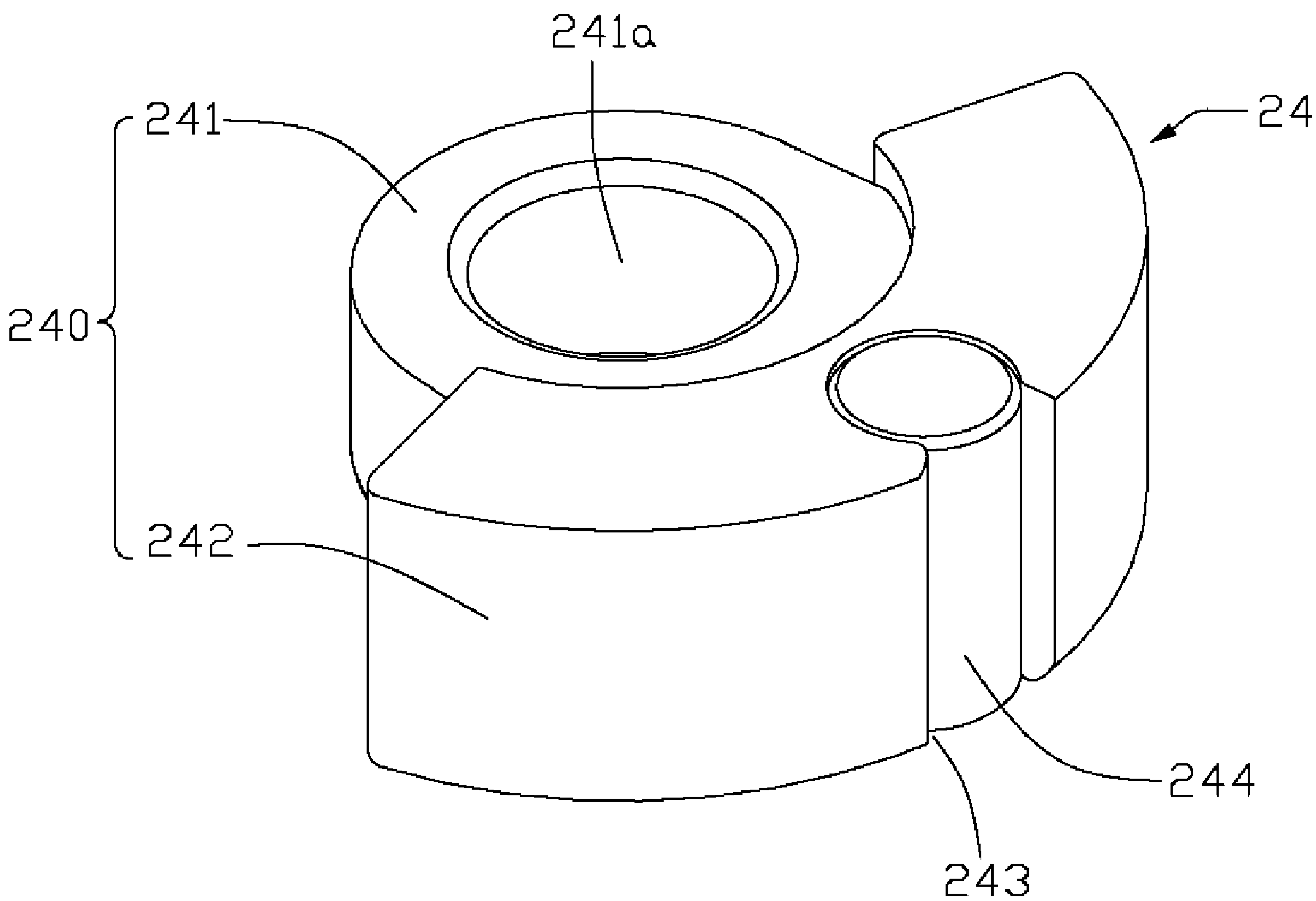

FIG. 4

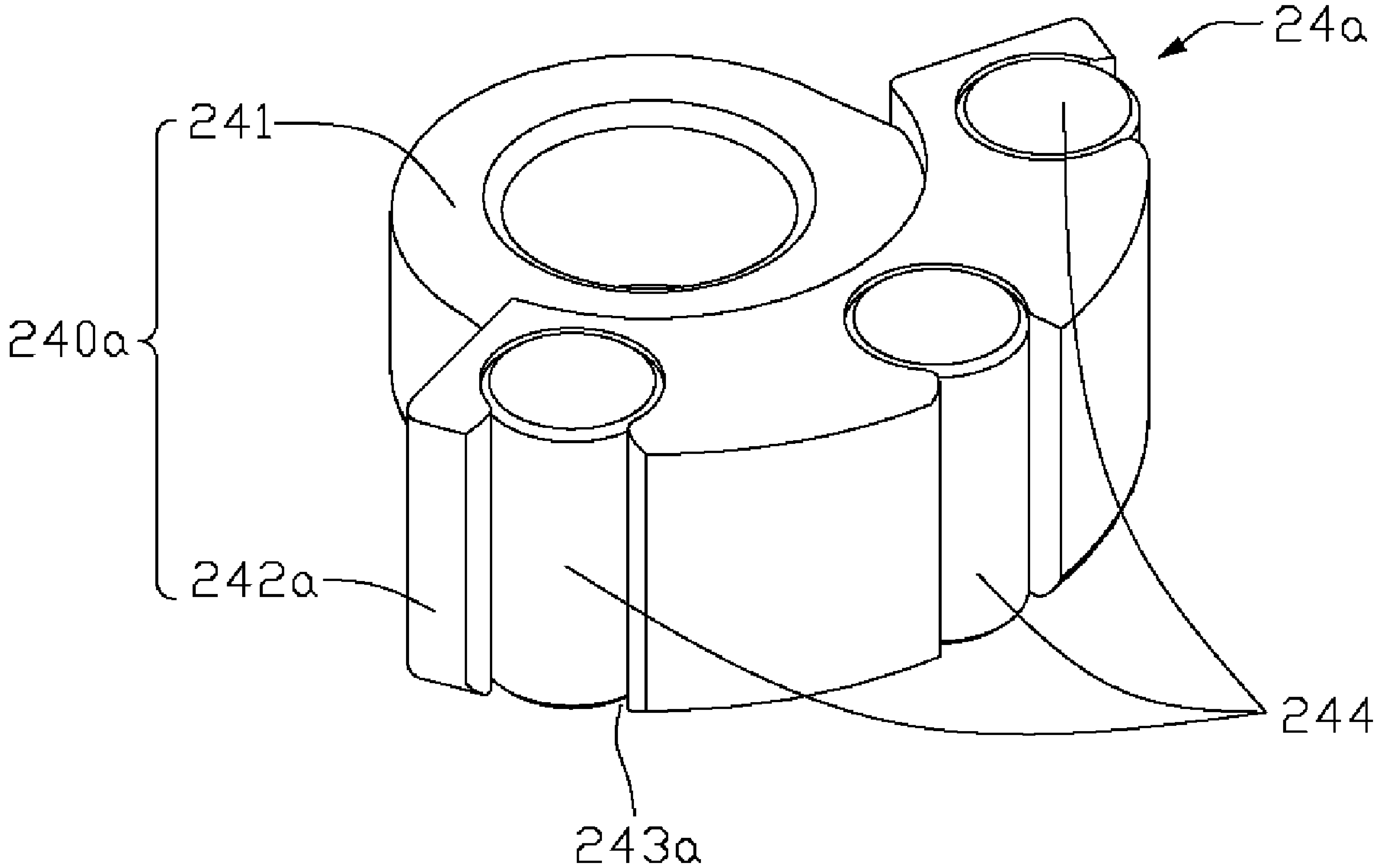

FIG. 5

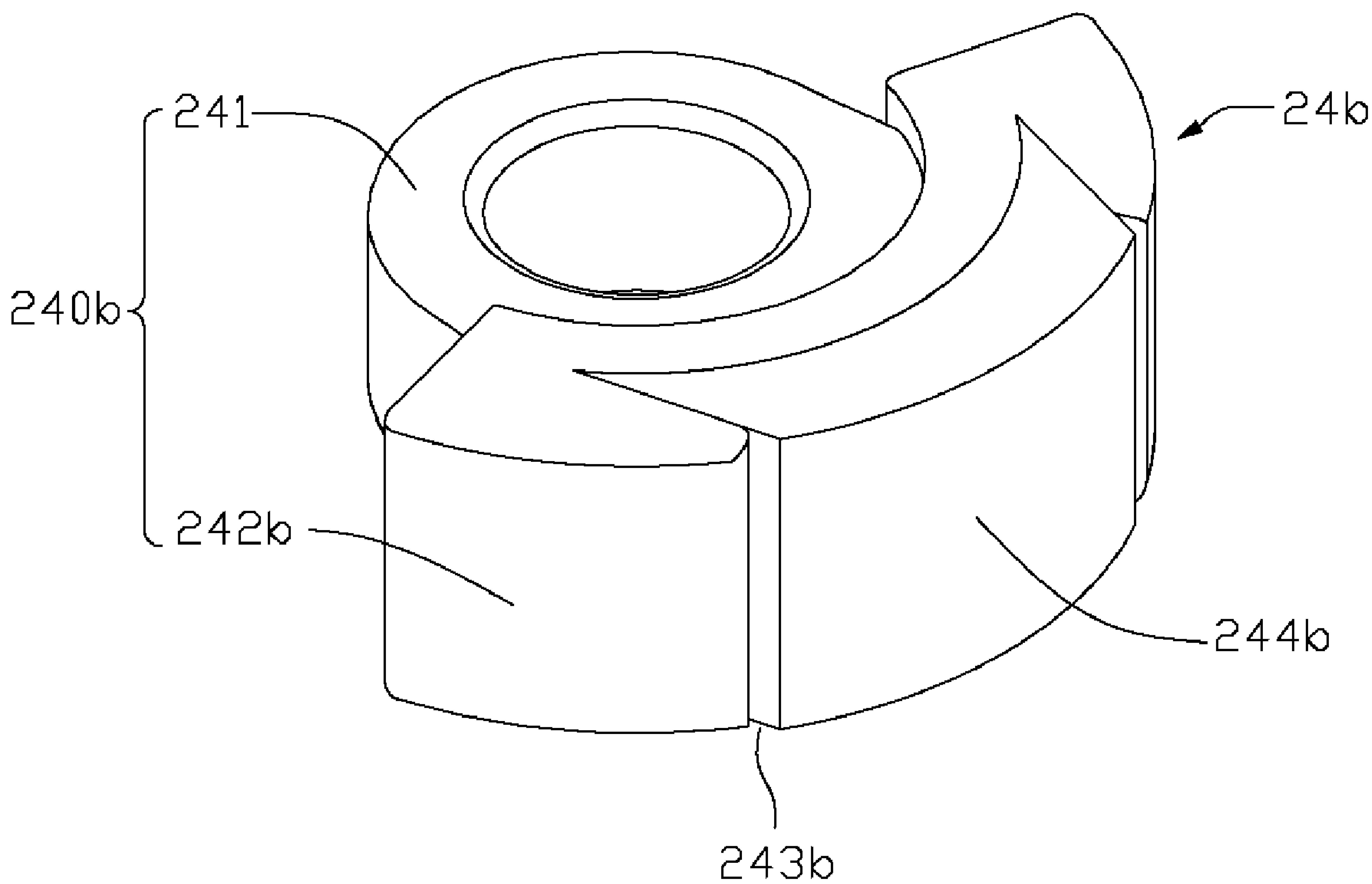

FIG. 6

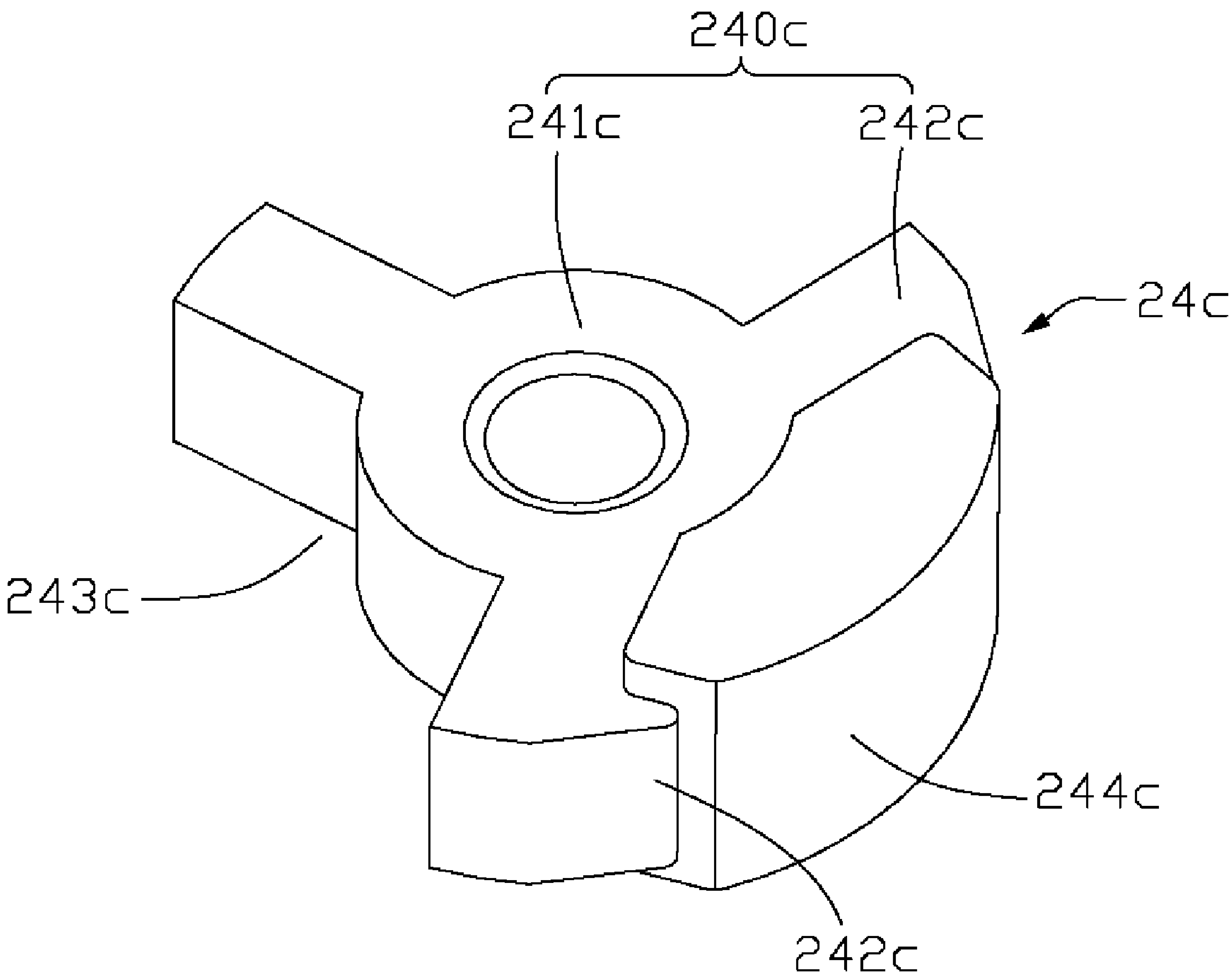

FIG. 7

ECCENTRIC ROTOR AND VIBRATION MOTOR INCORPORATING THE ECCENTRIC ROTOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to a vibration motor, and more particularly to an eccentric rotor of the vibration motor.

2. Description of Related Art

Mechanical vibrations are required for many different applications. Such as vibrations for material pulverization and selection in industrial use, vibration for home massage machines, and silent notification of incoming calls and messages for mobile phones, are but a few examples of mechanical vibration applications.

There are various methods that can be used to produce mechanical vibrations. One method involves the use of electric motors. A conventional type of vibration motor includes a casing receiving a stator therein, a shaft connected with the stator, and a rotor being rotatably disposed around the shaft. The rotor includes a bearing mounted around the shaft and an eccentric weight attached to the bearing. Vibration is produced by the rotation of the rotor as a result of the eccentric weight attached to the rotor. However, the eccentric weight is usually made of copper. A density of the copper is about 8.9 g/cm^3, which is too small to enable the eccentric weight to generate a highly satisfied vibration effect.

SUMMARY OF THE INVENTION

According to a preferred embodiment of the present invention, a vibration motor includes a housing, a stator received in the housing and a rotor rotatably disposed in the stator. The stator includes two claw-pole assemblies arranged back-to-back, and a shaft fixedly connected with the two claw-pole assemblies. The rotor includes a bearing rotatably mounted around the shaft, a permanent magnet mounted around the bearing, and an eccentric weight fixedly attached to the permanent magnet. The eccentric weight includes a main body and at least one inserting portion having a density higher than that of the main body. The main body is made of plastic, bakelite, aluminum, copper, aluminum alloy or copper alloy, while the at least one inserting portion is made of tungsten or tungsten alloy. The at least one inserting portion is fixed to the main body at position near a periphery of the main body so that the at least one inserting portion is distant from a rotation center of the eccentric weight.

Other advantages and novel features of the present invention will be drawn from the following detailed description of a preferred embodiment of the present invention with attached drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

Many aspects of the present vibration motor can be better understood with reference to the following drawings. The components in the drawings are not necessarily drawn to scale, the emphasis instead being placed upon clearly illustrating the principles of the present vibration motor. Moreover, in the drawings, like reference numerals designate corresponding parts throughout the several views:

FIG. **1** is an isometric, exploded view of a vibration motor in accordance with a preferred embodiment of the present invention;

FIG. **2** is an isometric, assembled view of the vibration motor of FIG. **1**;

FIG. **3** is an isometric, assembled view of a stator of the vibration motor of FIG. **2**;

FIG. **4** is an isometric view of an eccentric weight of a rotor of the vibration motor of FIG. **2**;

FIG. **5** is similar to FIG. **4**, but shows the eccentric weight in accordance with a second embodiment of the present invention;

FIG. **6** shows an isometric view of a third embodiment of the eccentric weight; and

FIG. **7** shows an isometric view of a fourth embodiment of the eccentric weight.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIGS. **1-2**, a vibration motor according to a preferred embodiment can be used in a communication equipment, such as a calling machine, a mobile phone or the like, which includes a housing **30**, a stator **10** received in the housing **30**, and an eccentric rotor **20** being rotatably supported by the stator **10**.

The housing **30** is cylindrical-shaped, including a lower portion **30***b* and an upper portion **30***a* located above and facing the lower portion **30***b*. Alternatively the housing **30** can be integrally formed. Each of the lower and upper portions **30***a*, **30***b* defines a cutout **32***a*, **32***b* in a free end thereof. When assembled the free ends of the two portions **30***a*, **30***b* abut against each other, and cooperatively the cutouts **32***a*, **32***b* define a passage in the housing **30** for connecting the motor with a power source (not shown). It is to be understood that the passage can be only formed in one of the portions **30***a*, **30***b* of the housing **30**, according to the shape of the stator **10**, for conveniently connecting the motor to the power source.

Also referring to FIG. **3**, the stator **10** includes upper and lower claw-pole assemblies **11** having size and shape the same with each other. Each of the claw-pole assemblies **11** includes an outer yoke **10***a* and an inner yoke **10***b* facing towards each other. Each of the inner yokes **10***b* of the claw-pole assemblies **11** is ring-shaped with a circular hole **14** defined therein. A plurality of pole teeth **16***a*, **16***b* extend perpendicularly from an inner circumference of each yoke **10***a*, **10***b*. Each tooth **16***a*, **16***b* forms an arc-shaped free end. In this embodiment, each yoke **10***a*, **10***b* forms five teeth **16***a*, **16***b*. It is to be understood that the number of the teeth **16***a*, **16***b* formed on the yokes **10***a*, **10***b* is decided by the precision requirement of the motor, being not limited to the disclosed embodiment. The pole teeth **16***a*, **16***b* of the yokes **10***a*, **10***b* are evenly spaced from each other along a circumferential direction thereof and thus define a plurality of slots **19** therebetween. Each pole tooth **16***a*, **16***b* has a shape and size the same as those of other teeth **16***a*, **16***b*. Each of the slots **19** has a size a little larger than that of the tooth **16***a*, **16***b* so as to receive a corresponding tooth **16***a*, **16***b* therein when the outer and inner yokes **10***a*, **10***b* are assembled together.

A circular-shaped mounting portion **14***a* is formed at a central portion of each of the outer yokes **10***a*. Five ribs **18***a* extend outwardly and radially from each mounting portion **14***a* to connect the mounting portion **14***a* with a periphery (not labeled) of the outer yoke **10***a*. The ribs **18***a* are evenly spaced from each other along a circumferential direction of the mounting portion **14***a* and are connected with the periphery of the outer yoke **10***a* between each two neighboring teeth **16***a*. The mounting portion **14***a* has an axis coincidental with that of the outer yoke **10***a*. A through hole **141***a* is defined in the mounting portion **14***a* with an axis coincidental with the axis of the mounting portion **14***a*. Several mounting holes **140***a* are defined in the mounting portion **14***a* around the through hole **141***a* and are evenly spaced from each other along the circumferential direction of the mounting portion **14***a*. The inner yoke **10***b* of each claw-pole assembly **11** forms two apertures **120** therein, and a pair of protrusions **122**. The protrusions **122** of the upper inner yoke **10***b* extend downwardly therefrom, while the protrusions **122** of the lower inner yoke **10***b* extend upwardly therefrom. The apertures **120** and the protrusions **122** are alternately arranged and evenly spaced from each other along the circumferential direction of the inner yokes **10***a*. A pair of pins **13***b* are integrally formed with and extend outwardly from an outer periphery of each inner yoke **10***b*. The two pins **13***b* of each inner yoke **10***b* are spaced from and parallel to each other.

Each of the outer yokes **10***a* combines with a corresponding inner yoke **10***b* to form the claw-pole assembly **11**. The inner yoke **10***b* and the outer yoke **10***a* of each claw-pole assembly **11** face to each other. The teeth **16***a* of each outer yoke **10***a* insert into the slots **19** of the corresponding inner yoke **10***b*, and the teeth **16***b* of each inner yoke **10***b* insert into the slots **19** of the corresponding outer yoke **10***a*. Thus the pole teeth **16***a*, **16***b* of the two yokes **10***a*, **10***b* of each claw-pole assembly **11** are intermeshed with each other. Along the circumferential direction of yokes **10***a*, **10***b*, the teeth **16***a*, **16***b* of the outer and inner yokes **10***a*, **10***b* of the claw-pole assembly **11** are arranged alternatively, and are separated from each other by an electrical angle of 180°. The teeth **16***a*, **16***b* of the yokes **10***a*, **10***b* of the claw-pole assembly **11** cooperatively form a cylindrical-shaped sidewall (not labeled) for coils (not shown) wound thereon. A narrow gap is defined between each two neighboring pole teeth **16***a*, **16***b*. The gaps between the teeth **16***a*, **16***b* are filled with resin inserted through the mounting holes **140***a* of the mounting portions **14***a* of the outer yokes **10***a* by insert molding; thus, the inner and outer yokes **10***a*, **10***b* are fixedly combined together to form the claw-pole assembly **11**.

The two claw-pole assemblies **11** are then arranged back-to-back to form the stator **10** of the motor. The circular holes **14** of the inner yokes **10***b* cooperatively define a space receiving the rotor **20** therein. The two claw-pole assemblies **11** are located at two opposite upper and lower ends of the motor symmetrically. The inner yokes **10***b* of the two claw-pole assemblies **11** abut each other and are located approximately in a middle of the stator **10**. The protrusions **122** of each inner yoke **10***b* extend into the apertures **120** of the other inner yoke **10***b* to fixedly assemble the two claw-pole assemblies together. The outer yokes **10***a* of the two claw-pole assemblies **11** are spaced from each other. The outer yoke **10***a* of the upper claw-pole assembly **11** is located at a top end of the stator **10**, whilst the outer yoke **10***a* of the lower claw-pole assembly **11** is located at a bottom end of the stator **10**. A shaft **23** is received in the space of the stator **10** with top and bottom ends thereof being fixedly received in the through holes **141***a* of the mounting portions **14***a* of the outer yokes **10***a* of the claw-pole assemblies **11**. An axis of the shaft **23** is coincidental with that of the stator **10**.

The eccentric rotor **20** includes a bearing **22** mounted around the shaft **23** and rotatable in respect thereto, a permanent magnet **26** mounted around the bearing **22**, and an eccentric weight **24**. The bearing **22** is received in the space of the stator **10** and located between the mounting portions **14***a* of the outer yokes **10***a*. A pair of spacers **25***a*, **25***b* made of highly abrasion-resistant material are respectively arranged on top and bottom ends of the bearing **22** for avoiding friction or impact between the bearing **22** and the outer yokes **10***a* during rotation of the rotor **20**. The permanent magnet **26** is ring-shaped, and is received in the space of the stator **10**. An outer diameter of the magnet **26** is approximately the same as or a little smaller than an inner diameter of the stator **10**. An inner diameter of the magnet **26** is much larger than an outer diameter of the bearing **22** and thus an interspace is defined therebetween. The eccentric weight **24** is received in the interspace and sandwiched between the magnet **26** and the bearing **22**. Alternatively, the eccentric weight **24** can be adhered to an outer surface of the magnet **26**. In this case, the inner diameter of the magnet **26** is approximately the same as the outer diameter of the bearing **22** and adhered to an outer surface of the bearing **22**.

The eccentric weight **24** includes a main body **240** and an inserting portion **244** received in the main body **240**. The main body **240** is made of plastic, bakelite, aluminum, copper or its alloy, including a cylinder **241** mounted around the bearing **22** through interference and a weight **242** integrally formed with the cylinder **241**. The cylinder **241** defines an axial hole **241** a receiving the bearing **22** therein. The weight **242** is substantially arc-shaped, and extends from an outer-periphery of the cylinder **241**. The weight **242** has a height larger than that of the cylinder **241**, and top and bottom ends of the weight **242** are located outside top and bottom ends of the cylinder **241** of the main body **240**. An outer surface of the weight **242** is adhered to an inner surface of the magnet **26** by adhesive. Thus the bearing **22**, the magnet **26** and the eccentric weight **24** are fixedly assembled together. A column-shaped slot **243** is defined in an outer periphery of the weight **242** of the main body **240**. Along a circumferential direction of the weight **242**, the slot **243** is located in a middle portion. The inserting portion **244** has a size and shape the same as that of the slot **243** of the weight **242**. A cross section of the inserting portion **244** along a direction perpendicular to an axial direction thereof is circular shaped. In other words, the inserting portion **244** has a configuration like an elongate, round shaft. When the inserting portion **244** is inserted into the slot **243**, top and bottom surfaces of the inserting portion **244** are coplanar with the top and bottom surfaces of the weight **242**, respectively. The inserting portion **244** is made of tungsten or tungsten alloy, which has a density about 19.36 g/cm^3 and being much larger than that of the main body **240**. The inserting portion **244** is fixedly mounted in the weight **242** of the main body **24** by interferential fit so that the inserting portion **244** rotates with the main body **24** when the motor is in operation. Alternatively, the inserting portion **244** can be fixedly attached to the weight **242** by riveting or soldering.

During assembly, the rotor **20** and the stator **10** are received in the housing **30**. The two claw-pole assemblies **11** are separated from each other by an electrical angle of 90°. The pins **13***b* of the two inner yokes **10***b* are alternatively arranged; one pin **13***b* of each inner yoke **10***b* is located between the two pins **13***b* of the other inner yoke **10***b*. The four pins **13***b* are parallel to each other and located at a same plane. Two coils (not shown) respectively wind around the sidewalls formed by the intermeshed pole teeth **16***a*, **16***b*. Each coil has two ends connected to the two pins **13***b* of a corresponding inner yoke **10***b* to be electrically connected to the power source. The rotor **20** is rotatably mounted around the shaft **23**. During operation, currents are applied to the coils by the power source. An alternating magnetic field is thus generated by the stator **10** to interact with the magnetic field established by the permanent magnet **26** to drive the rotor **20** of the motor into rotation. As the weight **242** of the eccentric weight **24** is arc shaped, a center of gravity of the rotor **20** is offset from an axis of rotation, thereby vibration is produced due to the eccentricity of weight of the rotor **20**. As the inserting portion **244** has much larger density than that of the main body **240**, the weight of the eccentric weight **24** of the rotor **20** is increased. Accordingly, when the rotor **20** is rotated, the vibration motor in accordance with the present invention will have a better vibration effect. Moreover, since the inserting portion **244** is located adjacent to an outer periphery of the weight **242** which is far from the axis of the rotation, the vibration effect can be enhanced.

FIG. **5** shows an alternative embodiment of the eccentric weight of the rotor of the motor. The difference of the second embodiment over the first embodiment is that the weight **242***a* of the main body **240***a* of the eccentric weight **24***a* defines three slots **243***a* therein. The slots **243***a* are evenly spaced from each other along the circumferential direction of the weight **242***a*. Three inserting portions **244** are respectively received in the slots **243***a*. Also the inserting portions **244** are made of tungsten or tungsten alloy to increase the weight of the eccentric weight **24***a* and further move a center of weight of the eccentric weight **24***a* away from the rotation center. It is to be understood that the number of the inserting portions **244** can be changed according to the vibration intensity requirement of the vibration motor, being not limited to the disclosed embodiments.

FIGS. **6**-**7** shows the inserting portions of the eccentric weights have different shapes. In these embodiments, the inserting portions **244***b*, **244***c* of the eccentric weights **24***b*, **24***c* have cross sections being irregular shaped. Alternatively, the inserting portions **244***b*, **244***c* can be cones or cuboids. As shown in FIG. **6**, the eccentric weight **24***b* includes a cylinder **241** and a weight **242***b*. The weight **242***b* defines a slot **243***b* therein. The inserting portion **244***b* is fixedly received in the slot **243***b*. The inserting portion **244***b* has a shape approximately the same as, but has a size larger than that of the slot **243***b*. When the inserting portion **244***b* is assembled with the main body **240***b*, the inserting portion **244***b* has a smaller part extending radially to an outside of the weight **242***b*. FIG. **7** shows a fourth embodiment of the eccentric weight. The main body **240***c* of the eccentric weight **24***c* includes a cylinder **241** c and three weight **242***c* extend radially and outwardly from the cylinder **241***c*. The cylinder **241***c* and the weights **242***c* have the same height. The three weights **242***c* are evenly spaced from each other along the circumferential direction of the cylinder **241***c* and thus define three slots **243***c* each between two neighboring weights **242***c*. The inserting portion **244***c* has a height larger than that of the main body **240***c*. When the inserting portion **244***c* is mounted into a slot **243***c* of the main body **240***c*, top and bottom surfaces are located outside top and bottom ends of the main body **240***c*.

It is understood that the invention may be embodied in other forms without departing from the spirit thereof. Thus, the present example and embodiment is to be considered in all respects as illustrative and not restrictive, and the invention is not to be limited to the details given herein.

What is claimed is:

1. A vibration motor, comprising:

a housing;

a stator received in the housing, comprising two claw-pole assemblies arranged back-to-back and a shaft being fixedly connected with the two claw-pole assemblies; and

a rotor being rotatably disposed in the stator, the rotor comprising a bearing being rotatably mounted around the shaft, a permanent magnet mounted around the bearing, and an eccentric weight being fixedly attached to the permanent magnet, the eccentric weight comprising a main body and at least one inserting portion having a density higher than that of the main body; and

wherein each claw-pole assembly comprises inner and outer yokes facing towards each other, a plurality of pole teeth extending from each of the yokes of each claw-pole assembly and being intermeshed with those of the other yoke, each outer yoke comprising a mounting portion concaved from a middle portion of each outer yoke towards the other outer yoke, the mounting portion defining a through hole with one end of the shaft being fixedly received therein and a plurality of mounting holes for resin being inserted therethrough to fill gaps between each two neighboring pole teeth.

2. The vibration motor of claim **1**, wherein the eccentric weight is sandwiched between the permanent magnet and the bearing.

3. The vibration motor of claim **1**, wherein the main body is made of one of the following materials: plastic, bakelite, aluminum, copper, aluminum alloy and copper alloy, and comprises a cylinder mounted around the bearing and a weight extending outwardly therefrom and being integrally formed with the cylinder, the inserting portion being received in the weight of the main body.

4. The vibration motor of claim **3**, wherein the at least one inserting portion is made of one of tungsten and tungsten alloy.

5. The vibration motor of claim **4**, wherein the at least one inserting portion is fixedly mounted in the weight of the main body by soldering.

6. The vibration motor of claim **3**, wherein the at least one inserting portion comprises several portions being symmetrically mounted in the weight.

7. The vibration motor of claim **1**, wherein the at least one inserting portion has one of the following shapes: column, cone, cuboid and irregular-shape.

8. The vibration motor of claim **1**, wherein the inner yokes of the two claw-pole assemblies abut against each other, each inner yoke forming at least a protrusion thereon and defining at least an aperture receiving the at least a protrusion of the other inner yoke therein.

9. The vibration motor of claim **1**, wherein the two claw-pole assemblies are mounted around the rotor symmetrically.

10. The vibration motor of claim **4**, wherein the at least one inserting portion is fixedly mounted in the weight of the main body by riveting.

11. The vibration motor of claim **4**, wherein the at least one inserting portion is fixedly mounted in the weight of the main body by interferential fitting.

12. The vibration motor of claim **1**, wherein an outer surface of the eccentric weight contacts an inner surface of the permanent magnet.

13. The vibration motor of claim **1**, wherein each inner yoke is ring-shaped with a circular hole defined therein, the bearing being received in the circular holes of the inner yokes and located between the outer yokes, a pair of spacers respectively arranged on top and bottom ends of the bearing for avoiding friction between the bearing and the outer yokes during rotation of the rotor.

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